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The Brush Alternating Current Electric Lighting System

THE BRUSH ELECTRIC COMPANY,

CLEVELAND, OHIO, U. S. A.

Advantages

OF

The Brush Long Distance Incandescence Electric Lighting System.

I.—A SYSTEM requiring only one-quarter as much copper wire as other systems.

* * * * * *

II.—A SYSTEM practically self-regulating.

* * * * * *

III.—A DYNAMO that will not burn out, like all alternating machines heretofore produced.

* * * * * *

IV.—A DYNAMO which yields in electric current a much larger percentage of the driving power than any of the old alternating forms.

* * * * * *

V.—A DYNAMO which will run and give light with one or more of its coils cut out.

* * * * * *

VI.—AN ARMATURE with removable and interchangeable coils.

* * * * * *

VII—AN ARMATURE which can be taken apart, changed, repaired or replaced within a few minutes by a single unskilled man with his own hands.

* * * * * *

VIII.—A DYNAMO so insulated that a serious shock could be received only by criminal carelessness.

* * * * * *

IX.—CONVERTERS thoroughly ventilated and insulated, running cool and perfectly reliable.

* * * * * *

X.—CONVERTERS of large sizes—up to a thousand lights or more—entirely self-regulating; no necessity of "banking" the converters or complicating the system with single small converters for each consumer.

* * * * * *

XI.—CONVERTERS arranged for 50 or 100 volts, which the user can alter from one to the other by a simple change of coupling whenever desired.

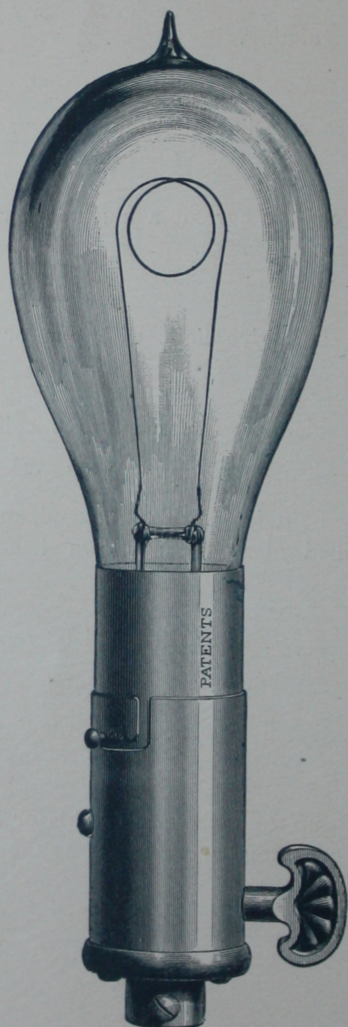
* * * * * *

XII.—AMMETERS, VOLTMETERS AND STATION INSTRUMENTS of exceedingly simple pattern and not liable to change in register.

XIII.—DETAILS OF MINOR APPARATUS, simple, and yet designed and constructed with skill and care Such details are often slighted and serious troubles result. The Brush Electric Company's system presents details as thoroughly worked out for their specific purposes as the dynamos and converters themselves.

***　　　***

IN GENERAL.—RELIABILITY, EFFICIENCY, ECONOMY, SIMPLICITY, EASY REPAIR, FLEXIBILITY AND PERFECTION OF DETAIL. A handsome profit under adverse conditions which, with other systems, would entail a loss.



INCANDESCENCE LAMP AND KEY SOCKET.

THE BRUSH ELECTRIC COMPANY'S
NEW ALTERNATING CURRENT SYSTEM.*

THE system of long distance transmission of electrical energy, which we illustrate herewith, is characterized in a high degree by efficiency and simplicity.

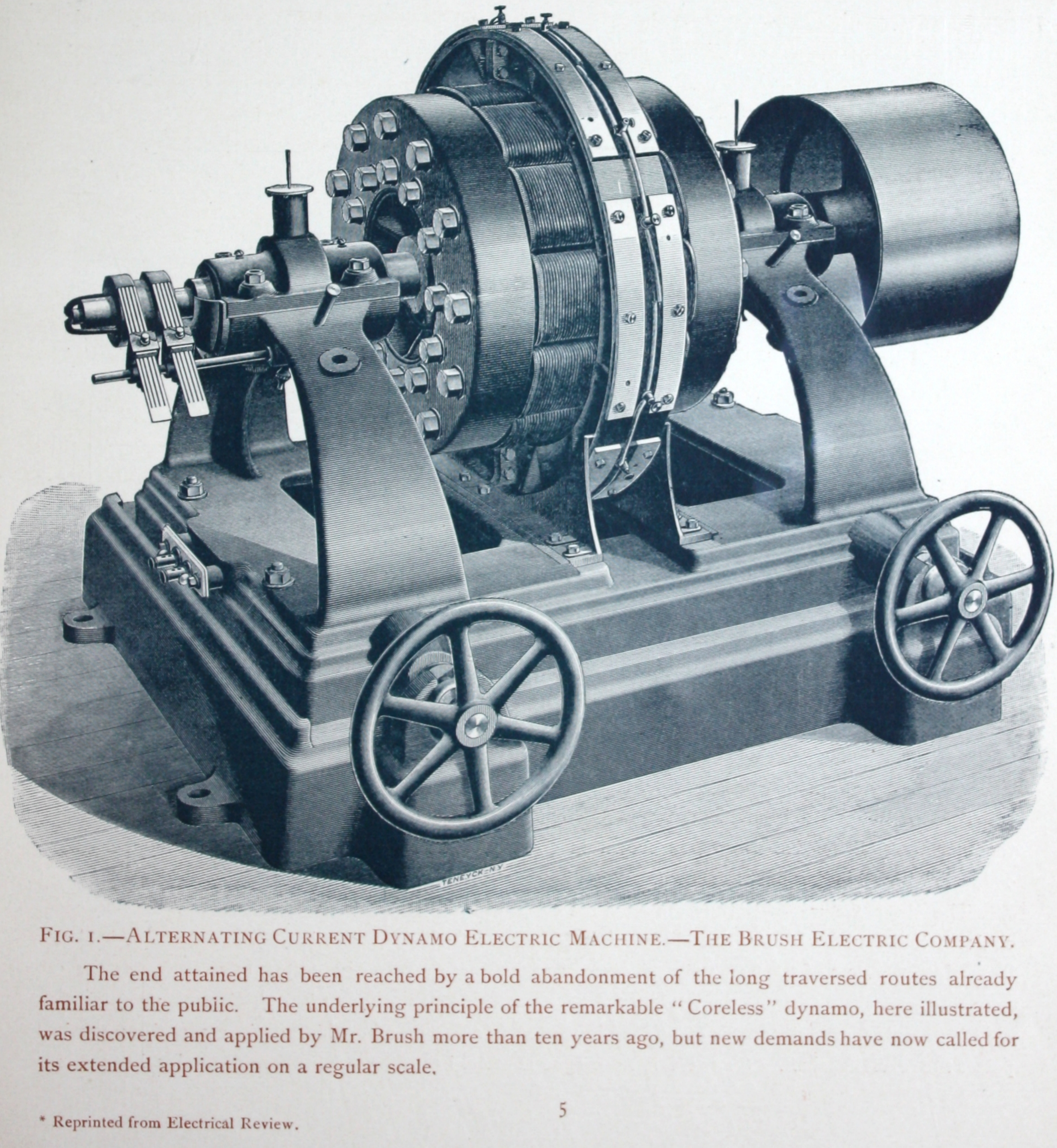


FIG. 1.—ALTERNATING CURRENT DYNAMO ELECTRIC MACHINE.—THE BRUSH ELECTRIC COMPANY.

The end attained has been reached by a bold abandonment of the long traversed routes already familiar to the pubiic. The underlying principle of the remarkable "Coreless" dynamo, here illustrated, was discovered and applied by Mr. Brush more than ten years ago, but new demands have now called for its extended application on a regular scale.

* Reprinted from Electrical Review.

The first glance at the dynamo (Fig. 1) shows that it is novel, compact, simple, symmetrical, and strong. Its field magnets, which are many, are carried by the shaft; the armature is fixed and absolutely free from any magnetic material; its parts are easily accessible, and an armature coil may be cut out of circuit, removed or replaced without stopping the machine.

The machine chosen for illustration and description has an output of 60,000 watts; it supplies current for a thousand 16-candle power lamps.

The shaft bearings, bearing standards, base plate and armature slides are cast in one solid piece. The center line of the shaft is 16 and 11-16th inches above the surface of the base plate, high enough for access to all parts of the dynamo and low enough for steadiness and freedom from strain on foundations. The four-inch steel shaft (tapering to three and a half inches in the bearings) carries two heavy cast iron yoke pieces, 27 inches in diameter. To each of these are screwed, at equal radial and circumferential distances, the wrought iron cores of twelve magnets of alternating polarity. The two yoke pieces, with their bolts, washers, etc., weigh about 950 pounds; the magnet cores, 308; the magnet wire, 400. Thus the whole rotating mass of cast iron, wrought iron, and copper, acts as a fly wheel weighing more than 1,700 pounds, and tending to neutralize any variation in the speed of the prime generator. As the nominal speed of the machine is fewer than 1,100 revolutions per minute, the structural strength is more than sufficient to meet all demands made by centrifugal force. Further than this, the mechanical stress is less when the magnets are excited than when the alternator is running without load, as the lines of magnetic force between the faces of opposing poles tend to counteract centrifugal force. In machines of larger size, as usual, the speed is less, that of the 150,000 watt dynamo being not more than 600 revolutions per minute. This larger alternator is driven by two belts, and carries a pulley at each end of its shaft. The great advantage of low shaft speed will be appreciated by every mechanic who has a due regard for depreciation of apparatus and cost of oil, attendance, trouble, and repairs.

The pulley has a 14-inch face. As it overhangs, the belt may be run to counter shafting overhead or below. The shaft bearing at the pulley end has 14 inches wearing surface, and the bearing at the other end 12 inches.

The most interesting part of the alternator is the fixed armature, shown in Figs 3 and 4. The vertical disc is occupied by flat armature coils, made of copper ribbon wound on supports of insulating material. The copper ribbon of each coil is reinforced on either side with strong insulating material of the same thickness as the bobbin carriers (see Fig. 5). One of these reinforcements is grooved and the other tongued. The coil, consisting thus of core, ribbon, and reinforcements, has an angular width of 60 degrees. The upper part of each face of each coil is covered with an insulating plate 5-16 of an inch thick. The coil thus built up and insulated is set in German silver holders, cut from true turned rings and held together by sunk-headed screws, as shown in Figs. 3, 4, and 5. Each terminal of the copper ribbon connects with a binding post as shown.

The six armature coils thus mounted are carried in a German silver frame consisting of two semicircles bolted together on the line of the vertical diameter. The cross-section of this ring frame is girder-like. Into the slots of the frame slip the six mounted armature coils, the tongue on the edge of the one engaging with the groove on the edge of the next. The coils thus thrust into the intense magnetic field constitute a disc, nine-sixteenths of an inch in thickness, and with an opening in the centre through which passes the revolving shaft. As there is no magnetic metal in the armature there are no local currents to

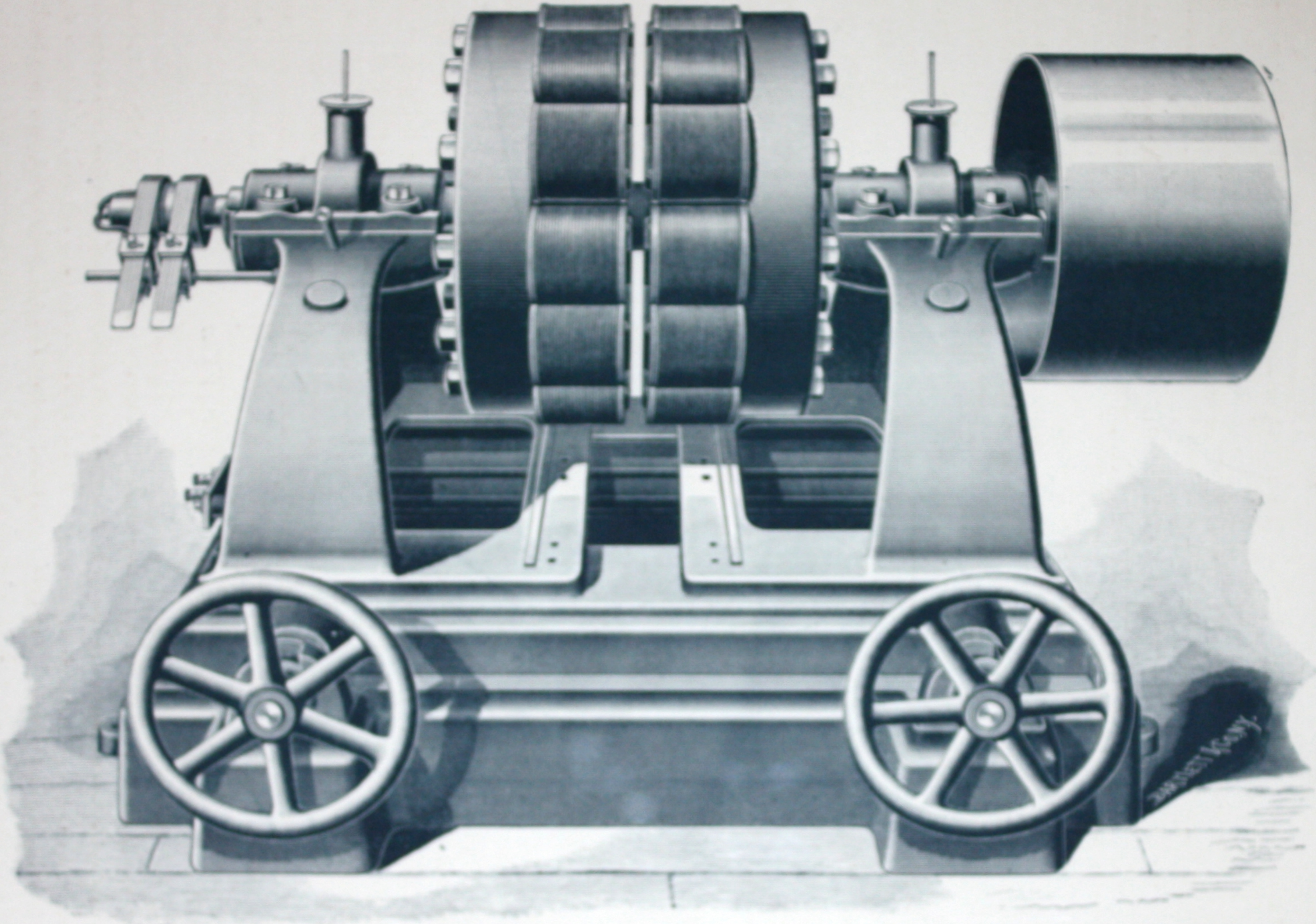


Fig. 2.—Alternator with Armature Removed.

waste the energy, consume the coal, burn out the armatures, interrupt the lights, irritate the customers, cut down profits, and discourage employer and employed.

The several coils are insulated carefully, and the stationary armature, as a whole, is insulated from the bed plate on which it rests. The coils are joined in series, the binding posts adjacent to any radial line of division between the two coils constituting fixed terminals for the main line. There is no commutator; there are no collecting brushes to take the alternating current from rotating parts.

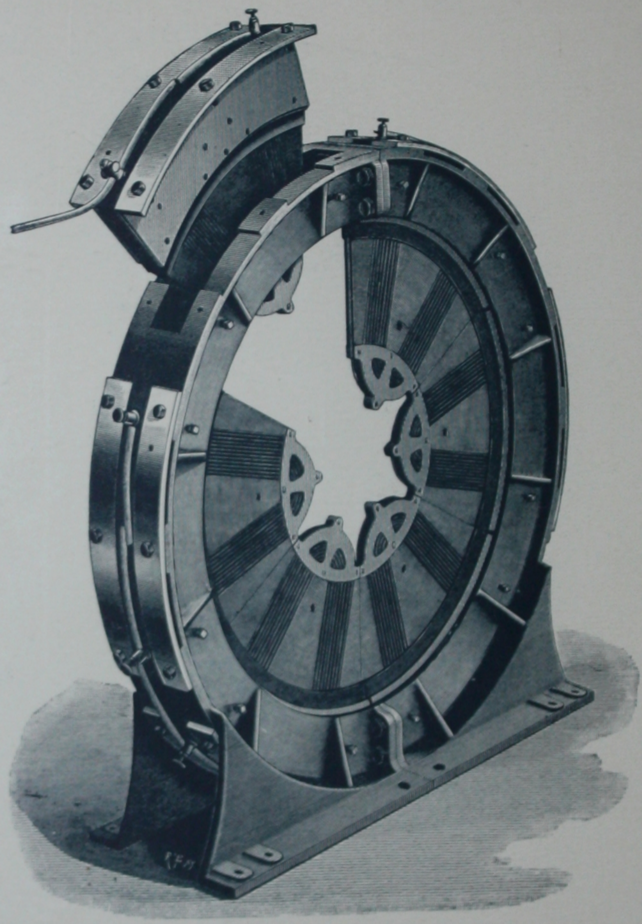


FIG. 3.—"CORELESS" ARMATURE, SHOWING DETACHABLE BOBBIN.

The low resistance of the armature coils is evident. It would seem impossible for one of them to burn out; none ever has burned out. But if one should, it may be removed and a new one readily put in its place in three minutes, or the injured coil may be shunted out of the circuit and the dynamo kept running with the other five until the time for shutting down. The coil section complete, with holder, etc., weighs only about 20 pounds.

The whole armature may be removed by loosening the coupling bolts and sliding each half of the frame with its three coils from between the field magnets (Fig. 4). As each half with its coils weighs only about 100 pounds, no time need be wasted on cranes or blocks, and in a few minutes the armature may be back in position. There is no necessity of keeping extra armatures on hand. If one wishes to feel wholly safe, a spare section or two will prove the utmost demand of precaution.

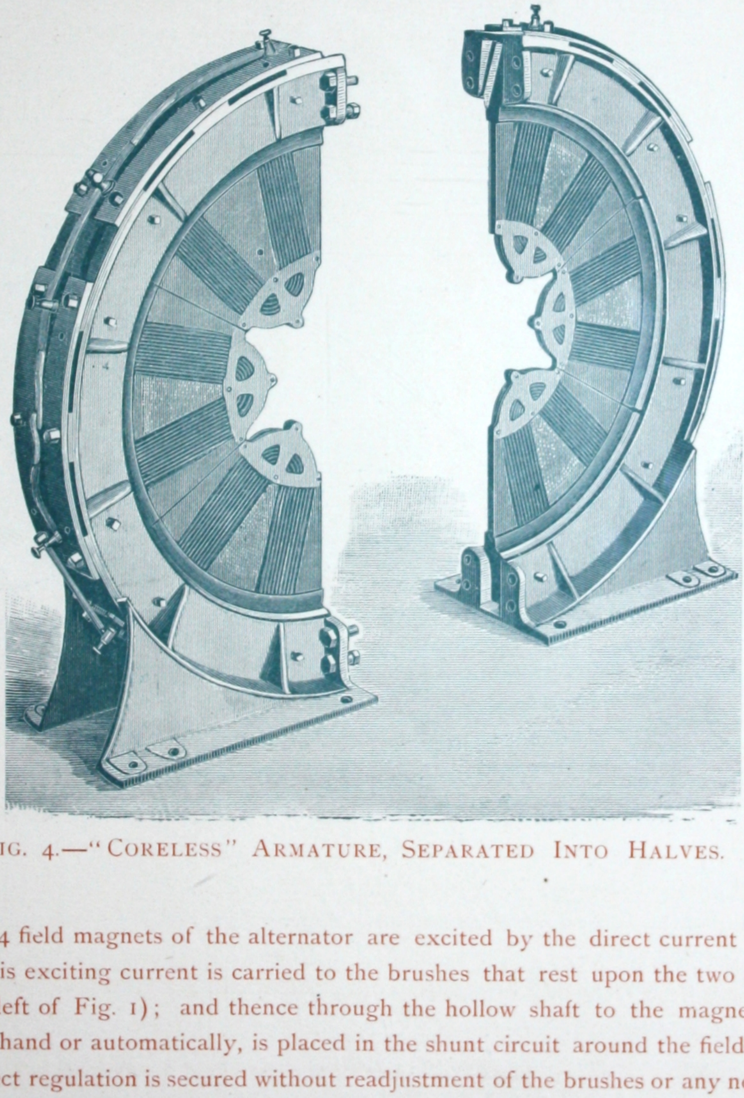


FIG. 4.—"CORELESS" ARMATURE, SEPARATED INTO HALVES.

In action, the 24 field magnets of the alternator are excited by the direct current from an 11 inch Brush dynamo. This exciting current is carried to the brushes that rest upon the two uncut insulating rings (shown at the left of Fig. 1); and thence through the hollow shaft to the magnets. A rheostat (Fig. 6), worked by hand or automatically, is placed in the shunt circuit around the field magnets of the exciter, so that perfect regulation is secured without readjustment of the brushes or any necessity of handling the high tension alternating current.

The desire for a magnetic field of maximum intensity has hitherto led to massive magnets encircling armatures with hundreds of pounds of iron core, upon which was wound a thin layer of conducting wire. But rapid magnetization and demagnetization involve molecular movement of some kind, and this move-

ment develops heat. No wonder, then, that when the iron molecules have their magnetic polarity reversed several hundred times a second, they should protest against such treatment. This heat of ferric indigation interferes with cupric conductivity, is destructive to insulation, and, in course of time, is likely to destroy the armature in spite of lamination, and perforation, and ventilation and power consuming reversed suction plates. Further than even this, the work of bringing about all these evils must be paid for in motive power—the candle is burned at both ends.

With clear recognition of these undoubted facts and their economic bearings, the electrical advisers of the Brush Electric Company made no attempt to sub-divide and ventilate a magnetic armature core, but promptly threw it overboard as a mistaken contrivance for alternating dynamos. However, a revolving armature without a metal core was liable to be structurally weak. This and other considerations led to the fixed armature without any iron projecting into the magnetic field and, as its necessary complement, the rotating magnets.

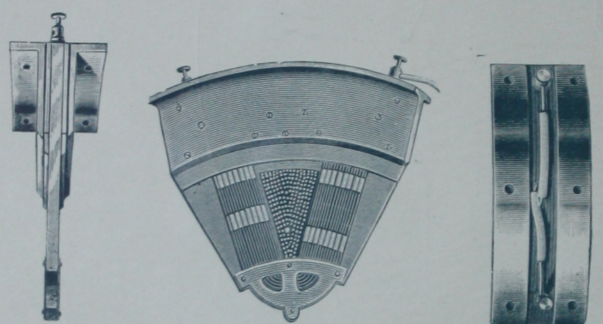


Fig. 5.—Detached Bobbin, or Section of Armature.

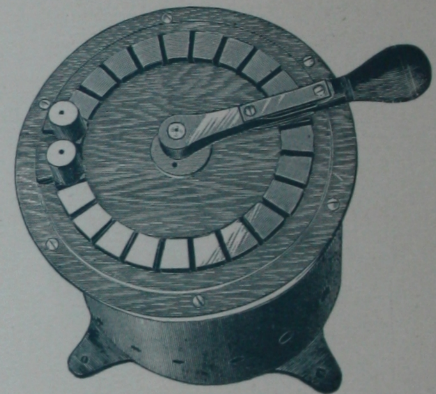


Fig. 6.—Regulator.

The Brush-Pfannkuche "coreless" alternator is built at present for an E. M. F. of 2,000 volts, although it would be easy to develop a difference of potential much greater. It is not improbable that the necessity of long distance transmission with a line of moderate cost will soon call for currents of higher tension. Economy of power as well as economy of copper points in this direction.

We here find a potential curve that varies little from a horizontal line. The fall of potential in the machine from no load is less than ten per cent., as is shown in Fig. 7, which represents a diagram taken from one of the first machines. All this without compound winding or artificial regulation of any kind, a result that has not been approached by any alternator with an iron core in its armature. All of the regulation needed is applied at the exciter, as already described.

This results in a more even distribution of potential in the feeders and at the converter terminals, and a more even pressure at the terminals of the lamps beyond.

For the information of those not yet familiar with the modern alternating current system of distribution, we may state that the high tension current of the Alternator is well adapted for economical carriage to distant points, but it is not of the kind most desirable for introduction to the household or for

use in the lamp. Having brought electric energy from the place where we wish to develop it to the place where we wish to use it, we may easily change the form given to it for economy of transportation and adapt it fully for the uses to which it is destined. The letter of credit may be exchanged for its equivalent in currency, but the cash box must be larger than the envelop. So in the present case, high tension may be exchanged for greater current, volts for amperes, what we have for what we want. This transformation is accomplished by the converter, a simple device with purely electrical functions and without moving parts.

The principle underlying the action of the converter is the well known principle of electrical induction. Imagine two coils of insulated wire, *A* and *C*, constituting closed circuits, Fig. 8. Thrust *C* into the thoroughly insulated core of *A*. When a current of electricity begins to flow through *C*, a momentary current will flow through the wire of *A*, and may be detected by the movement of the needle of the galvanometer, *B*. The current of *A* is not the current of *C*, but it is produced (or induced) by it, and

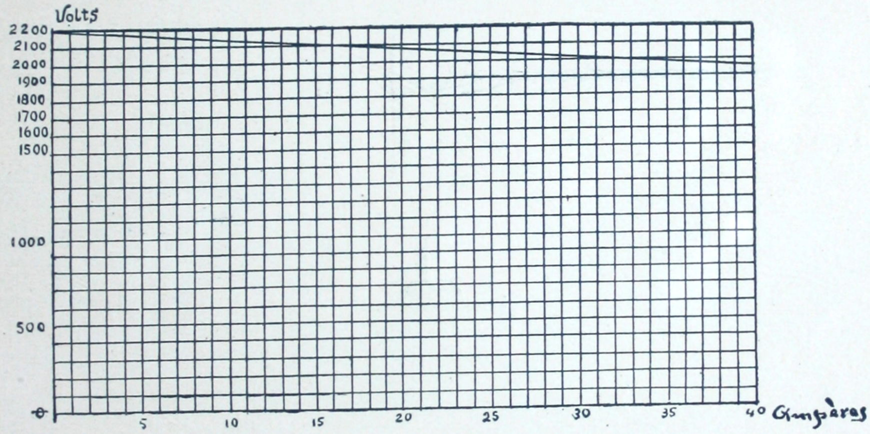


FIG. 7.—CURVE OF BRUSH–PFANNKUCHE ALTERNATOR WITHOUT ARTIFICIAL REGULATION. MAXIMUM LOAD, 30 AMPERES.

exists at its expense. This induced current in *A* is merely momentary; if the current continues to flow through *C*, there is no further electrical disturbance in *A*; the needle of the galvanometer rests at the zero point. If, however, the current of *C* is stopped, another current will be induced in *A*, the two currents thus induced being opposite in direction. Thus a succession of stops and starts of the current of *C* (the primary) induces a corresponding series of momentary currents in *A* (the secondary). The relation of the direct and induced currents will be determined by the constitution of the coils, *i.e.*, the size of the wire and the number of convolutions in the coils. Either coil may be exterior to the other, or the two may lie side by side. Of course, we are seeking merely to describe, not to explain this inductive action.

There can be no reversal without a stop and start. Consequently, the rapidly alternating current of the dynamo just described is of the character most efficient for the development of induced currents in the secondary coil. The two coils now described constitute a converter. It only remains properly to adjust its parts for the end in view and to work its effectiveness up to the maximum.

If, as is now well understood, the two coils be made alike, the size and length of the wire and the number of convolutions being the same, the induced current will resemble the inducing current, as to

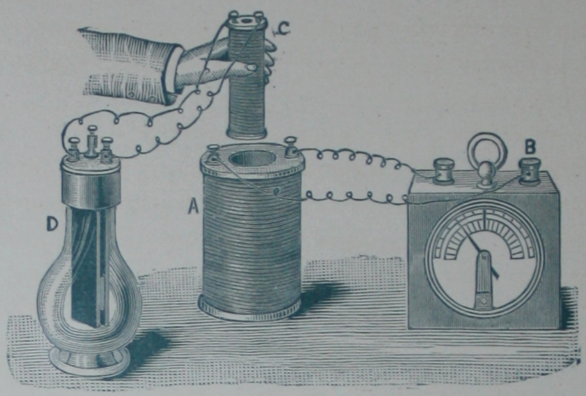


FIG. 8.

pressure (potential—E. M. F.—volts) and current strength (amperes). If the secondary coil be made of a greater number of turns of finer wire, the current strength will be reduced and the pressure correspondingly increased. This is the effect produced in the ordinary induction or Ruhmkorff coil. If, on the

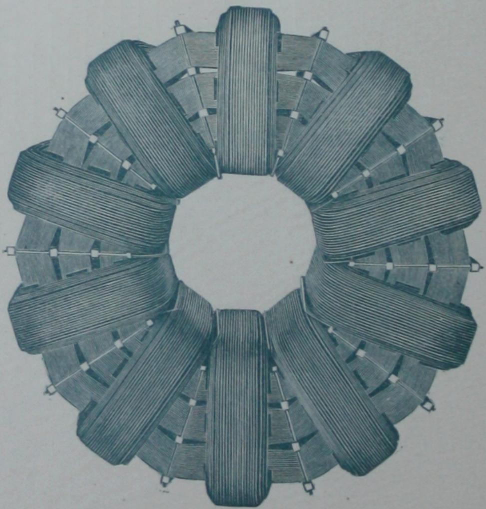


FIG. 9.—LARGE TYPE CONVERTER.

other hand, the secondary coil be made of fewer turns of larger wire, the pressure will be reduced and the current strength increased. This is the end we now desire, and the converter is thus constituted. As in

the Ruhmkorff coil and the armature of the ordinary dynamo, the inductive effect is heightened by an iron core. In the Brush Company's converter here represented (Fig. 9) the core consists of a polygonal ring made of insulated iron wire of the best quality, so wound as to leave several concentric air spaces in the core. In the converters of the smaller sizes, the core is built up of perforated thin iron plates (Fig. 10). In either case, the iron is so divided that the efficiency of the converter is little less with half than with full load.

Upon each side of this core or iron ring is wound a single layer of heavy copper wire. The four or five single layer coils carried by each half of the core are joined in series, and the two groups, borne by the two halves of the core, are joined in multiple, the whole constituting the secondary coil. The terminals of this secondary coil connect with the secondary main line running into houses and supplying current for the lamps. Most of the converters are wound so as to give a secondary current of about 100 volts, but may quickly be connected to give 50 volts and twice as many amperes as before. They are made in sizes that supply each from two to 250 sixteen candle-power lamps or more.

Between the fine iron of the core and the heavy copper wire of the superposed secondary coil insulating pads, one-eighth of an inch thick, are placed at the corners of the core. Between these insulating corner pieces are insulating air spaces. Thus, the copper and the iron are separated from each other at

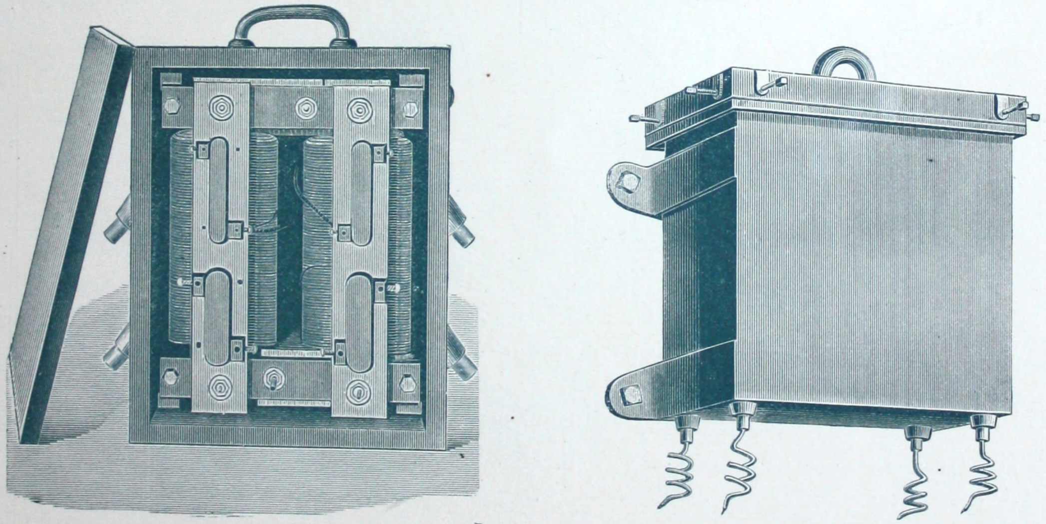


FIG. 10. SMALL TYPE CONVERTERS. Fig. 11.

the corners of the core by their respective coverings and the insulating pads, and at all other points by their respective coverings and open air spaces, the latter affording ample ventilation and facility of examination.

Over each of these single layer parts of the secondary coil are wound a few layers of smaller copper wire to form a corresponding part of the primary coil. These corresponding parts of the secondary and primary coils are separated from each other by insulating pads at the corners and intervening air spaces, in the same manner and with the same advantages as previously described (Fig. 9).

Nothing could be more satisfactory than the ventilation of these converters. The insulation resistance is exceedingly high. It is impossible so to overload the wire of the primary circuit as to force its current into the secondary circuit. In other words, the high tension current cannot pass the converter. The converters are tested at the factory with double load, and no one has given out. Yet, to make safety doubly sure, overloading is made impossible by the use of safety fuses for the primary coils. THESE ARE EXTRA LONG, SO MOUNTED ON SLATE OR PORCELAIN STRIPS THAT THEY MAY BE REMOVED OR REPLACED WITH THE FINGERS MERELY, AND WITHOUT TOUCHING ANY METALLIC PART OF THE CONVERTER.

The converter coils, with safety fuses, etc., are placed in wind and weather proof cast iron boxes of pleasing design (Figs. 11 and 12), and may be placed wherever most convenient, the governing principle being to do as much work as possible with the less expensive primary wire, and to shorten the more costly secondary main. Thus, the converter, as the local centre of distribution, is brought near the lamps it is to feed, and placed on the nearest line pole or on the wall of the building.

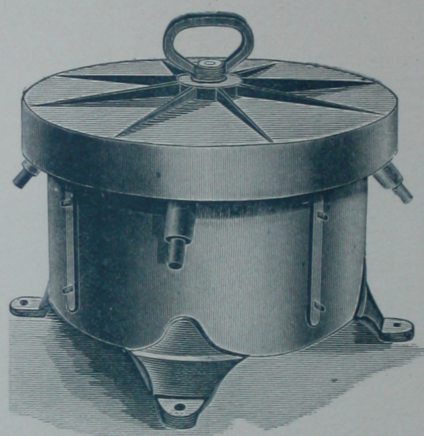


FIG. 12.—LARGE CONVERTER IN WEATHERPROOF CASE.

The Brush Electric Company's converters are now made of the following sizes:

No. 1,	which feeds 2 lamps.
No. 2,	which feeds 5 lamps.
No. 3,	which feeds 10 lamps.
No. 4,	which feeds 20 lamps.
No. 5,	which feeds 30 lamps.
No. 6,	which feeds 40 lamps.
No. 7,	which feeds 50 lamps.
No. 8,	which feeds 75 lamps.
No. 9,	which feeds 100 lamps.
No. 10,	which feeds 150 lamps.
No. 12,	which feeds 250 lamps.

Other sizes can be easily made as desired.

With converters as with dynamos, the larger sizes are the most economical. With a 100-volt converter fed by a 2,000-volt primary current, it is more easy and profitable to run a short secondary main to supply several consumers than to provide a converter for each consumer. Of course, the latter may be done if, for any reason, it seems desirable. But this desirability has been UNDULY MAGNIFIED BY THOSE MANUFACTURERS WHO HAVE FOUND THAT THEIR CONVERTERS OF LARGE SIZE ARE IMPRACTICABLE. On the other hand, the Brush Electric Company claims that even its 98 per cent. of efficiency is exceeded in the larger sizes and points out the additional important fact that as they are made of heavier wire in both primary and secondary coils, they are practically indestructible. There is no longer any need of placing a group of converters to feed a secondary main, or of furnishing a separate converter for each customer.

Fig. 13 represents the ammeter, a device placed in the main or feed circuit, wherever it is desirable to measure the strength of the current. It is a compensated expansion device (acting on the principle of

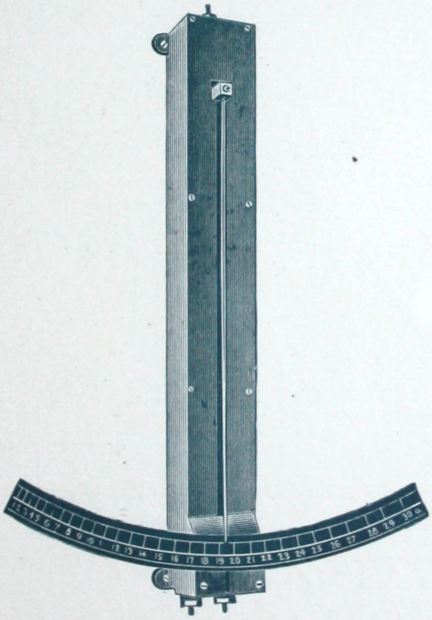


FIG. 13.

the lamp covered by Mr. Brush's patent. No. 219, 209, Sept. 1879). Free from any magnetic action, the simple compensating arrangement insures the normal working of the apparatus at all temperatures. It is equally efficient with direct and with alternating currents.

The alternating current apparatus of the Brush Electric Company here described is based on the patents of Charles F. Brush and Gustav Pfannkuche, the latter having the special supervision of this branch of the Brush Electric Company's electrical engineering work. Large orders for this apparatus have been taken, and its commercial success is fully assured.

THE

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UNDER THE PATENTS OF CHAS. F. BRUSH AND OTHER INVENTORS OF

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BRUSH AND PFANNKUCHE PATENTS.

DYNAMO SIZES.

No. 3, Alternator,	Capacity, 600 Lights.	No. 4, Alternator,	Capacity, 1,000 Lights.
No. 6, Alternator,	Capacity, 2,500 Lights.		

CONVERTER SIZES.

No. 1,	Capacity, 2 Lights. Or One Light, 32 Candle Power.	No. 6,	Capacity, 40 Lights.
" 2,	" 5 "	" 7,	" 50 "
" 3,	" 10 "	" 8,	" 75 "
" 4,	" 20 "	" 9,	" 100 "
" 5,	" 30 "	" 10,	" 150 "
		" 12,	" 250 "

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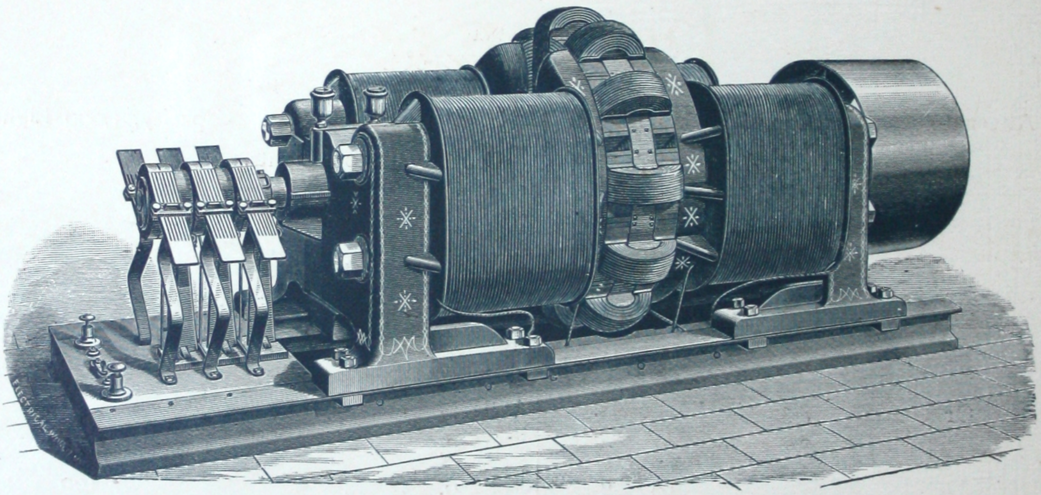

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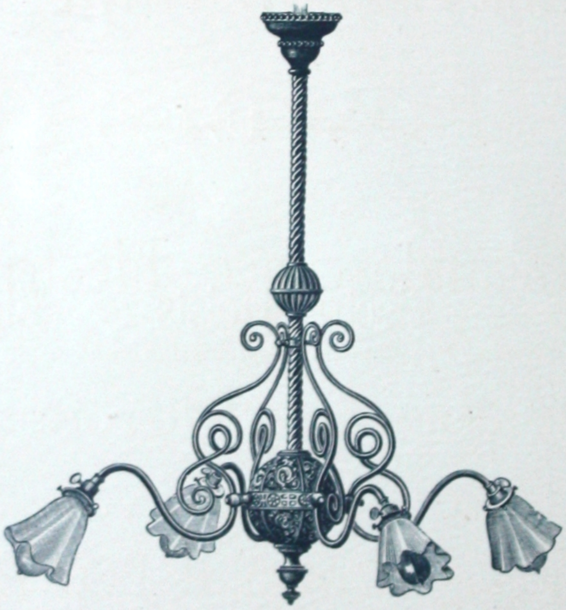

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DOES NOT AFFECT TELEPHONE OR FIRE ALARM SERVICE.

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